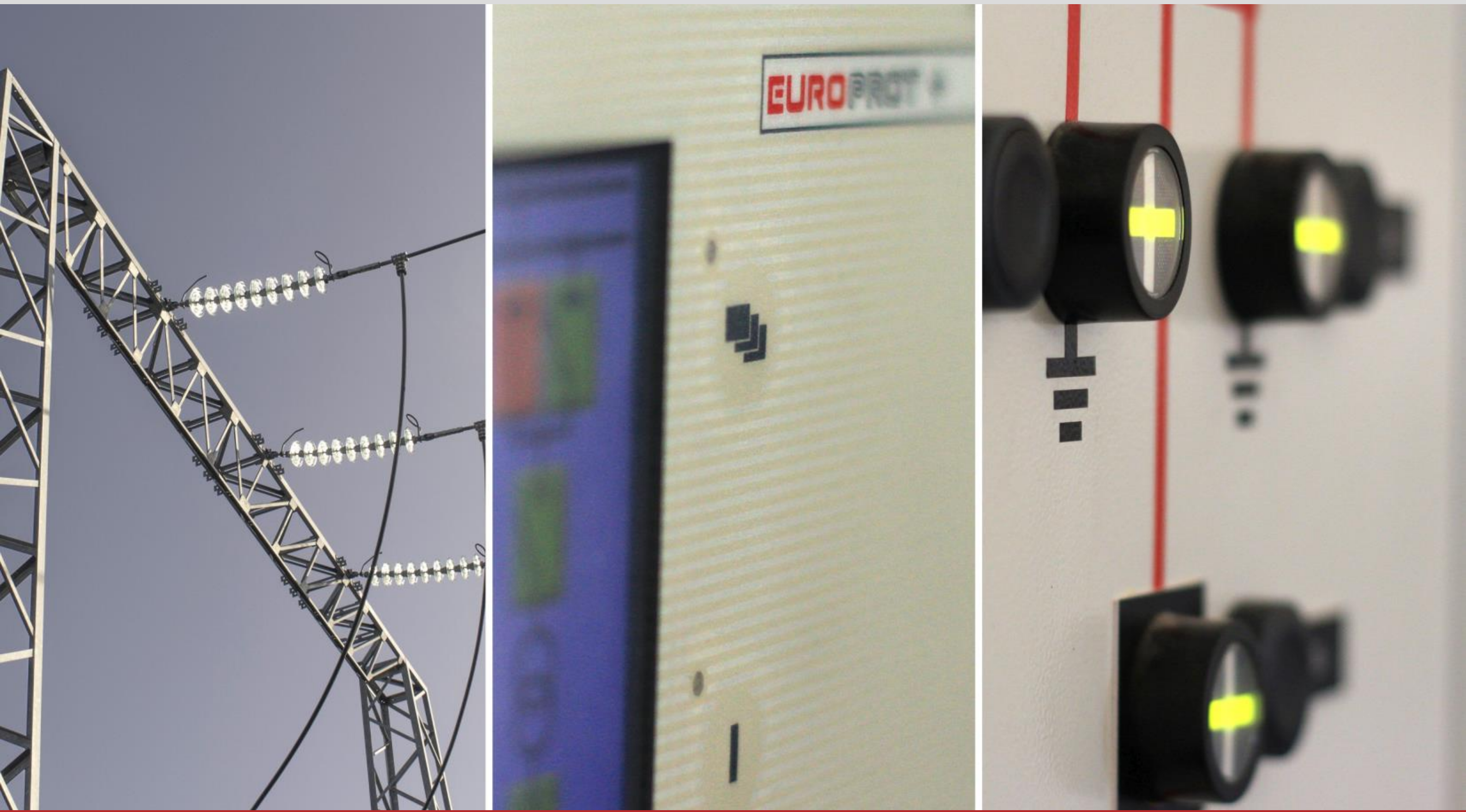

FUNCTION BLOCK DESCRIPTION

Inrush current detection

DOCUMENT ID: PP-13-22394
VERSION: 3.0
2024-12-20, BUDAPEST

PROTECTION, AUTOMATION AND
CONTROL FOR POWER INDUSTRY

VERSION INFORMATION

VERSION	DATE	MODIFICATION	COMPILED BY
1.0	2010-11-11	First edition	Petri
2.0	2021-08-10	New design, new chapters (overview, notes for testing) added	Saina, Erdős
3.0	2024-12-20	Graphical analogue inputs added, IEC61850 info added	Erdős

CONTENTS

1 Application

When an inductive element with an iron core (transformer, reactor, etc.) is energized, high current peak values can be detected. This is caused by the transient asymmetric saturation of the iron core as a nonlinear element in the power network. The sizing of the iron core is usually sufficient to keep the steady state magnetic flux values below the saturation point of the iron core, so the inrush transient slowly dies out. These current peaks depend also on random factors such as the phase angle at energizing. Depending on the shape of the magnetization curve of the iron core, the detected peaks can be several times above the rated current peaks. Additionally, in medium or high voltage networks, where losses and damping are low, the indicated high current values may be sustained at length. Figure 1-1 shows a typical example for the inrush current shapes of a three-phase transformer.

As a consequence, overcurrent relays, differential relays or distance relays may start, and because of the long duration of the high current peaks, they may generate an unwanted trip command.

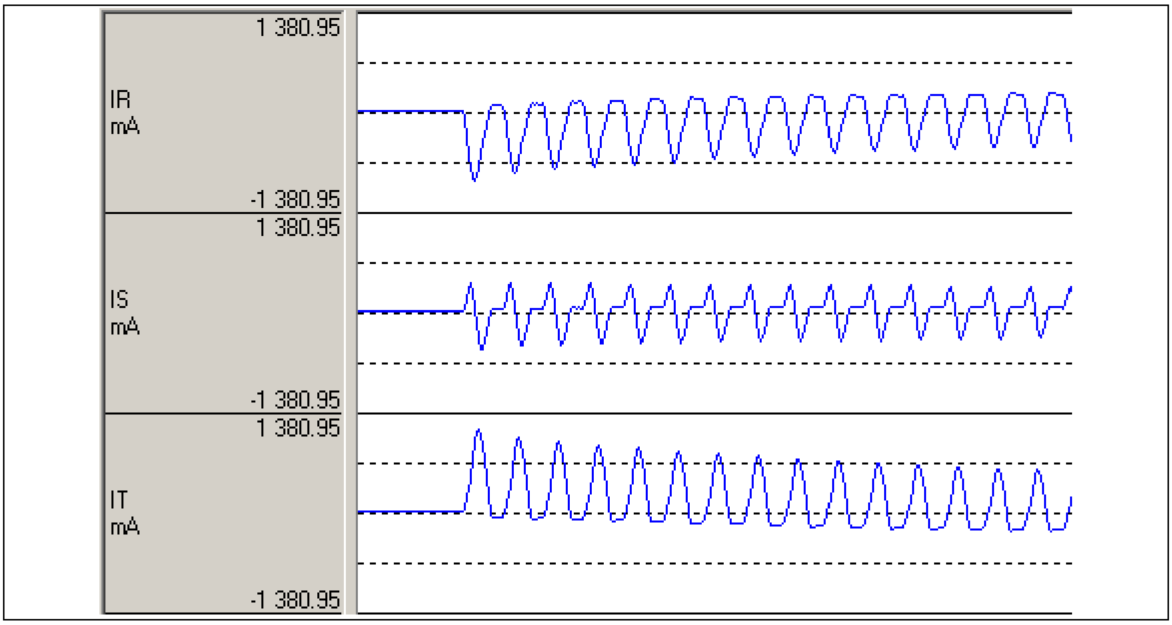

Figure 1-1 Example: A typical inrush current

The inrush current detection function can distinguish between high currents caused by overload or faults and the high currents during the inrush time.

Using the inrush detection binary signals, other protection functions can be blocked during the transient period so as to avoid the unwanted trip.

Some protection functions use these signals automatically, but a stand-alone inrush detection function block is also available for application at the user’s discretion.

1.1 Mode of operation

The operating principle of the inrush current detection function is based on the special shape of the inrush current.

As Figure 1-1 shows, the typical inrush current in one or two phases is distorted and asymmetrical to the time axis: for example, in IT of the Figure above the positive peaks are high while no peaks can be detected in the negative domain.

The theory of the Fourier analysis states that even harmonic components (2^{nd}, 4^{th} etc.) are dominant in waves distorted as described above. The component with the highest value is the second one.

Typical overload and fault currents do not contain high even harmonic components.

The inrush current detection function processes the Fourier basic harmonic component and the second harmonic component of the three phase currents. If the ratio of the second harmonic and the base Fourier harmonic is above the setting value of the parameter 2nd Harm Ratio, an inrush detection signal is generated.

The signal is output only if the base harmonic component is above the level defined by the setting of the parameter Base sensitivity. This prevents unwanted operation in the event that low currents contain relatively high error signals.

The function operates independently using all three phase currents individually, and additionally, a general inrush detection signal is generated if any of the phases detects inrush current.

The function can be disabled by the binary input INR2_**Blk**_GrO_. This signal is the result of logic equations graphically edited by the user.

The **inputs** of the inrush current detection function are

- the basic and second Fourier components of three phase currents,
- binary input,
- parameters.

The **output** signals of the inrush current detection function are

- inrush detection in phases L1, L2 or L3 individually,
- a general inrush detection signal.

2 Inrush current detection function overview

The function block of the inrush current detection function is shown in Figure 2-1. This block shows all binary input and output status signals that are applicable in the graphic equation editor.

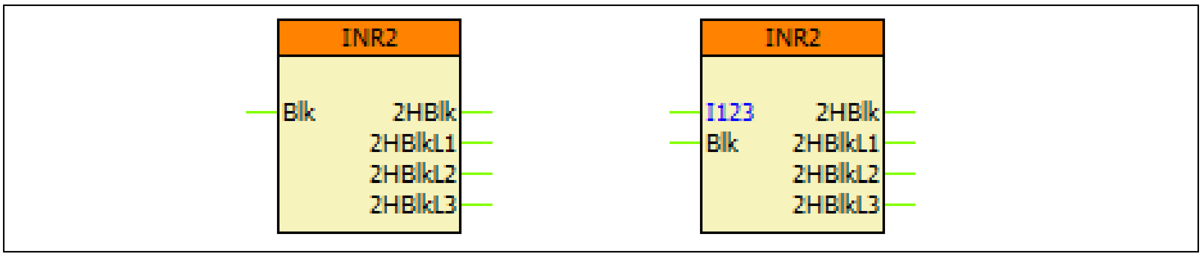

Figure 2-1 The function block of the inrush current detection function

2.1 Settings

2.1.1 Parameters

The available parameters are listed below in order of their appearance in the *parameters* menu. If the setting range of a parameter should be extended, contact Protecta Support.

Table 2-1 Parameters of the inrush current detection function

TITLE	DIM	RANGE	STEP	DEFAULT	EXPLANATION
Operation	-	Off, On	-	Off	Enabling the function
2nd Harm Ratio	%	5 – 50	1	15	Ratio of the second harmonic Fourier component and the basic harmonic component.
Base sensitivity	%	20 – 100	1	30	The function operates only if the base harmonic component is be above this setting

2.2 Function I/O

This section briefly describes the analogue and digital inputs and outputs of the function block.

2.2.1 Analogue inputs

The basic and second Fourier components of three phase currents.

Graphic Analogue inputs *(only from firmware version 2.10.2.3010 and up)*

The sources of the analogue inputs are defined by the user, applying the graphic equation editor (*Logic Editor*). Parts written in **bold** are seen on the left side of the function block in the Logic editor.

Table 2-2 Analogue input signals of the impedance protection function

ANALOGUE INPUT SIGNAL	SIGNAL TITLE	EXPLANATION
INR2_**I123**_AnIn_	3phase current	Input for 3-phase current

The applied analogue connectors must be identical to the analogue input type (i.e. voltage to voltage input etc.), Invalid connections are not allowed.

2.2.2 Binary input signals (graphed output statuses)

The conditions of the binary inputs are defined by the user, applying the graphic equation editor (*Logic Editor*). Parts written in **bold** are seen on the left side function block in the Logic editor.

Table 2-3 The binary input signal of the inrush current detection function

BINARY INPUT SIGNAL	EXPLANATION
INR2_**Blk**_GrO_	Blocking input of the function

2.2.3 Binary output signals (graphed input statuses)

These signals can be used in EuroCAP to assign to LED, user LCD object etc. Parts written in **bold** are seen on the right side of the function block in the *Logic Editor*.

Table 2-4 The binary output signals of the inrush current detection function

BINARY OUTPUT SIGNAL	SIGNAL TITLE	EXPLANATION
INR2_**2HBlk**_GrI_	Inrush	Inrush current detected in one of the three phases
INR2_**2HBlkL1**_GrI_	Inrush L1	Inrush current detected in phase L1
INR2_**2HBlkL2**_GrI_	Inrush L2	Inrush current detected in phase L2
INR2_**2HBlkL3**_GrI_	Inrush L3	Inrush current detected in phase L3

2.2.4 Online data

Visible values on the *online data* page.

Table 2-5 Online displayed data of the inrush current detection function

SIGNAL TITLE	DIMENSION	EXPLANATION
Inrush L1	-	Inrush current detected in phase L1
Inrush L2	-	Inrush current detected in phase L2
Inrush L3	-	Inrush current detected in phase L3
Inrush	-	Inrush current detected in one of the three phases
Current input assignment	-	*Status of the graphical analogue input (if exists)*

2.2.5 Events

The following events are generated in the event list, as well as sent to the SCADA according to the configuration.

Table 2-6 Generated events of the inrush current detection function

EVENT	VALUE	EXPLANATION	IEC61851 DATA ATTRIBUTE
2nd Harm. Restraint	off, on	Inrush current detected in one of the three phases	INRPHAR1STStr$general

2.3 Technical data

Table 2-7 Technical data of the inrush current detection function

FUNCTION	VALUE	ACCURACY
Current accuracy	20 – 2000% of In	±1% of In

2.4 Notes for testing

The differential protection function block (DIF87) has its own, built-in 2nd harmonic restraint feature which works independently from the function described here. For further information, see the Differential Protection Function description.

Keep in mind that there is a minimum requirement for the fundamental component of the current (% is the % of the CT nominal), and the function operates according to the 2nd harmonic content related to the fundamental component.

Additional notes for Graphic Analogue inputs *(only from firmware version 2.10.2.3010 and up):*

Starting from the firmware version **2.10.2.3010**, the majority of the function blocks can be updated to be equipped with graphic analogue inputs which **allow the user to assign the functions' analogue inputs by applying the graphic equation editor**.

The analogue connections of these functions can be checked by examining the source that is connected to their inputs (just like examining the source of a logic signal).

These functions must be placed in the Logic Editor and their graphic analogue inputs must be connected to make them operate. If a connection is intact, the online status of the corresponding analogue input will show "Complete". If it is missing, the status will be "Missing" and the function will not operate.

Note that these graphical inputs do not exist in the earlier firmware/function versions (2.8.x.xxxx)! Checking and modifying the analogue assignments in these cases are done by using the EuroCAP Software Configuration menu.